VARIABILITY IN MOTION ANALYSIS DUE TO EXPERIMENTER EXPERIENCE AND PROTOCOL

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INTRODUCTION

Marker based motion analysis has been used extensively as a tool to measure the kinematics of motion. The test-retest, intrarater, and inter-rater reliabilty of this tool has been quantified [1,2]. Advancements in technology have allowed for very precise measurement, 3D residual of less than 0.5mm for example. However, both the precision and accuracy of the tool are influenced by the ability of an examiner to identify bony landmarks, the manual location of markers at these landmarks, replicating this location on multiple occasions and, in general terms, the experience of an examiner.

With the increased availability of motion analysis equipment and turn-key analysis software, the assumptions of precision and accuracy of the system must be re-examined with the common confounding factor of experimenter experience. The purpose of this study was to examine the variability of a marker based motion analysis system using two different marker placement protocols and two different levels of investigative experience.

METHODS

Three biomechanics researchers (two Postdoctoral Fellows, and one Master of Science student) placed retro-reflective surface markers on one subject's left leg and foot. The examiners were asked to define the hip, knee and ankle joint centers, and the thigh, shank and foot segments. Two of the examiners used the same method for marker placement (Method 2) and the third examiner used Method 1 (Fig.1). The subject performed 10 walking trials at a self selected walking speed with each marker set on three separate days.

Fig. 1. Marker positions: (left to right) Method 1 with experienced examiner; Method 2 with experienced examiner; Method 2 with inexperienced examiner.

Data were collected using an eight-camera motion capture system (EVaRT, Motion Analysis) at 240 Hz and a force plate (Kistler AG, Switzerland) at 2400 Hz. The data were analyzed in Kintrak (University of Calgary, CANADA). Three dimensional kinematics were calculated for the ankle and knee joint, and for the thigh, shank and foot segments. Mean absolute variability (MAV), which is the maximum minus the minimum values for each frame averaged over all samples of the gait cycle [1], was calculated for each angle for the duration of stance. In addition, variance of specific parameters (e.g. maximum angle, time to maximum, touch-down and toe-off angle) was analyzed.

RESULTS AND DISCUSSION

The MAV comparing experimenter experience with the same protocol ranged from 1.366 to 2.776 degrees for ankle rotations, and from 1.632 to 3.641 degrees for knee rotations. The MAV for different protocols with similar experimenter experience ranged from 1.385 to 4.857 degrees for ankle rotations, and from 1.881 to 2.719 degrees for knee rotations. The largest variance was observed between the two placement protocols examining ankle plantar/dorsiflexion. The variability calculated for within protocol and between protocols was within the same range as previously reported [1, 2].

Two examples of noted differences between the experienced and inexperienced examiners marker placement were the identification of the greater trochanter, and the placement of the markers on the lower leg (Fig.1). The experienced examiner placed two anterior markers on the tibia where there is the least amount of surface artifact, and the inexperienced examiner placed the markers on the Tibialis Anterior muscle belly.

Although the MAV between protocols was in an acceptable range, when the motion profile is analyzed gaphically, as in Fig. 2, a second distinguishable peak in the knee flexion profile generated by Method 1 at approximatly 10% of stance is noted. This additional peak could be attributed to a stabilization of the knee as heel strike occurs, or it could be due to soft tissue movement creating a motion artifact. High speed video data should comfirm either possibility.

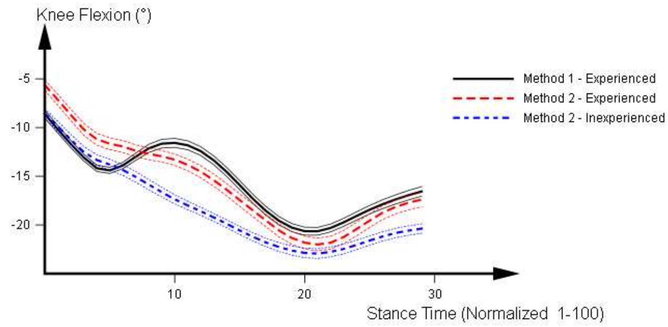

Fig. 2. Knee flexion during first 30% of stance (mean of 30 trials over three days with standard error).

This work provides evidence that in addition to mean absolute variability, the entire profile of the motion during stance should be considered when analyzing and comparing motion data.

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